INTERPRETATION OF NATIVE RANGE VEGETATION

FROM

1:500 70-mm LARGE-SCALE COLOR AND COLOR INFRARED PHOTOGRAPHY

Alberta
ENERGY AND NATURAL RESOURCES
Resource Evaluation and Planning Division

INTERPRETATION OF NATIVE RANGE VEGETATION FROM 1:500 70-mm LARGE-SCALE COLOR AND COLOR INFRARED PHOTOGRAPHY

by

R. Nesby
Renewable Resources Inventory Section
Resource Evalution and Planning Division

1986
Edmonton

ENR Technical Report Number: T/89
International Standard Book Number: 0-86499-241-6
Printed 1985 as the final report.

Anyone wishing to quote from this report or to use any part in any form should obtain written permission from the Resource Evaluation Branch, Energy and Natural Resources.

FOR ADDTIONAL COPIES OF THIS REPORT, CONTACT:

Information Centre
Alberta Energy and Natural Resources
Main Floor, Bramalea Building
9920 - 108 Street
Edmonton, Alberta, Canada, T5K 2M4

Phone: (403) 427-3590

ABSTRACT

A test project was undertaken in the Carbondale and Castle River Range Exclosure areas of Alberta during the summer of 1983. The purpose of this project was to evaluate how accurately native range vegetation could be interpreted from 70-mm format Kodak aerocolor negative 2445 and Kodak aerochrome infrared 2443 large-scale aerial photography (LSP).

A total of 117 sites were located on the ground. The vegetation found at each of these sites was tallied and each site location was subsequently pinpricked on the LSP.

Four air photo interpreters possessing varying levels of experience in interpreting range vegetation were tested to assess their ability at identifying native range vegetation species on the LSP.

Vegetation within the study area consisted primarily of a variety of native shrubs, forbs and grasses inherent to the southwestern region of Alberta.

The results of this project indicated that three of the four interpreters performed best while working with the color infrared (Kodak 2443) film emulsion. The four interpreters were ranked in their

ability at air photo interpretation, based upon their familiarity with native range vegetation, photo interpretation experience, experience with LSP as well as their familiarity with the project area. Interpreter A was the most experienced in all aspects, while Interpreter D was considered to be the least experienced.

The level of interpretation experience and familiarity with native range vegetation had a significant bearing on the interpreter's ability to interpret native range vegetation from 1:500 color (Kodak 2445) and color infrared (Kodak 2443), 70-mm large-scale aerial photography.

TABLE OF CONTENTS

	Page
1. INTRODUCTION	1
2. STUDY AREA	3
2.1 Location	3
3. METHODS	5
3.1 Office Preparation	5
3.2 Large-Scale Photo Acquisition System	6
3.3 Large-Scale Photo Acquisition	9
3.4 Track Recovery	11
4. FIELD SAMPLING	15
5. POST FIELD	17
5.1 Summarizing Field Data	17
5.2 Photo Interpretation	17
6. RESULTS	21
7. CONCLUSION	23
8. RECOMMENDATIONS	25
APPENDICIES 1	27
APPENDICIES 2	29
APPENDICIES 3	33
APPENDICIES 4	37
APPENDICIES 5	39
REFERENCES	41

LIST OF TABLES

Table		Page
1.	Cross Reference Table in Relating 1:2 000 Tracking Photography to 1:500 LSP	12
2.	Color and Color Infrared Range Vegetation Identified on 70-mm - 1:500 LSP in Castle and Carbondale Exclosure Areas	18
3.	Experience Levels of Interpreters A, B, C, D	20
4.	Summary of Interpretation Results for Interpreters A, B, C and D for Sites Where One Species Occurred	23

LIST OF FIGURES

Figure		Page
1.	Location of Large-Scale Photo Flight Lines in Study Area	4
2.	Bell 206B Helicopter with NoFRC LSP Acquisition System . .	7
3.	Instrumentation Rack for NoFRC Acqusition System	8

ACKNOWLEDGMENTS

I wish to thank Sharon Robertson, Forester, Resource Evaluation Branch, for contributing her knowledge and expertise in the Range Management.

I thank Ron Hall, Research Officer and Study Leader for the Northern Forest Research Centre, Canadian Forestry Service, for his assistance in LSP acquisition, technical review and for his encouragement in this project.

I also acknowledge the assistance and appreciate the opportunity to share ideas with fellow workers within Resource Evaluation Branch.

Dave Taylor and Alberto Parry, Resource Evaluation Branch are thanked for their assistance in making this report possible.

1. INTRODUCTION

Since the inception of the Large-Scale Photography (LSP) program within Alberta Energy and Natural Resources, attempts have been made only recently to expand the application of LSP to renewable resources other than forest inventory.

Due to the increasing demand upon provincial rangelands, an application of LSP was evaluated as an alternate method for identifying native rangeland vegetation.

The three objectives for this project were to answer the following questions:

1. Can native rangeland vegetation be accurately interpreted on LSP?

2. What degree of accuracy can be achieved through interpretation of native rangeland vegetation on LSP?

3. Which film emulsion, color infrared (Kodak 2443) or color (Kodak 2445), is best suited for the identification and quantification of native rangeland vegetation?

2. STUDY AREA

2.1 Location

The project areas were located within Forest Management Unit C3. That unit is located bewteen Blairmore, Alberta, Waterton Lakes National Park and the Alberta-British Columbia border. C3 is bordered on the east by Forest Management Unit C01 (Figure 1).

Two north-south, large-scale photo flight lines were exposed over the Castle Range Exclosure, which is located in Township 5, Range 3, west of the Fifth Meridian. Two additional east-west, large-scale photo flight lines were exposed over the Carbondale Range Exclosure, which is located in Township 6, Range 3, west of the Fifth Meridian. Each flight line was six kilometres in length.

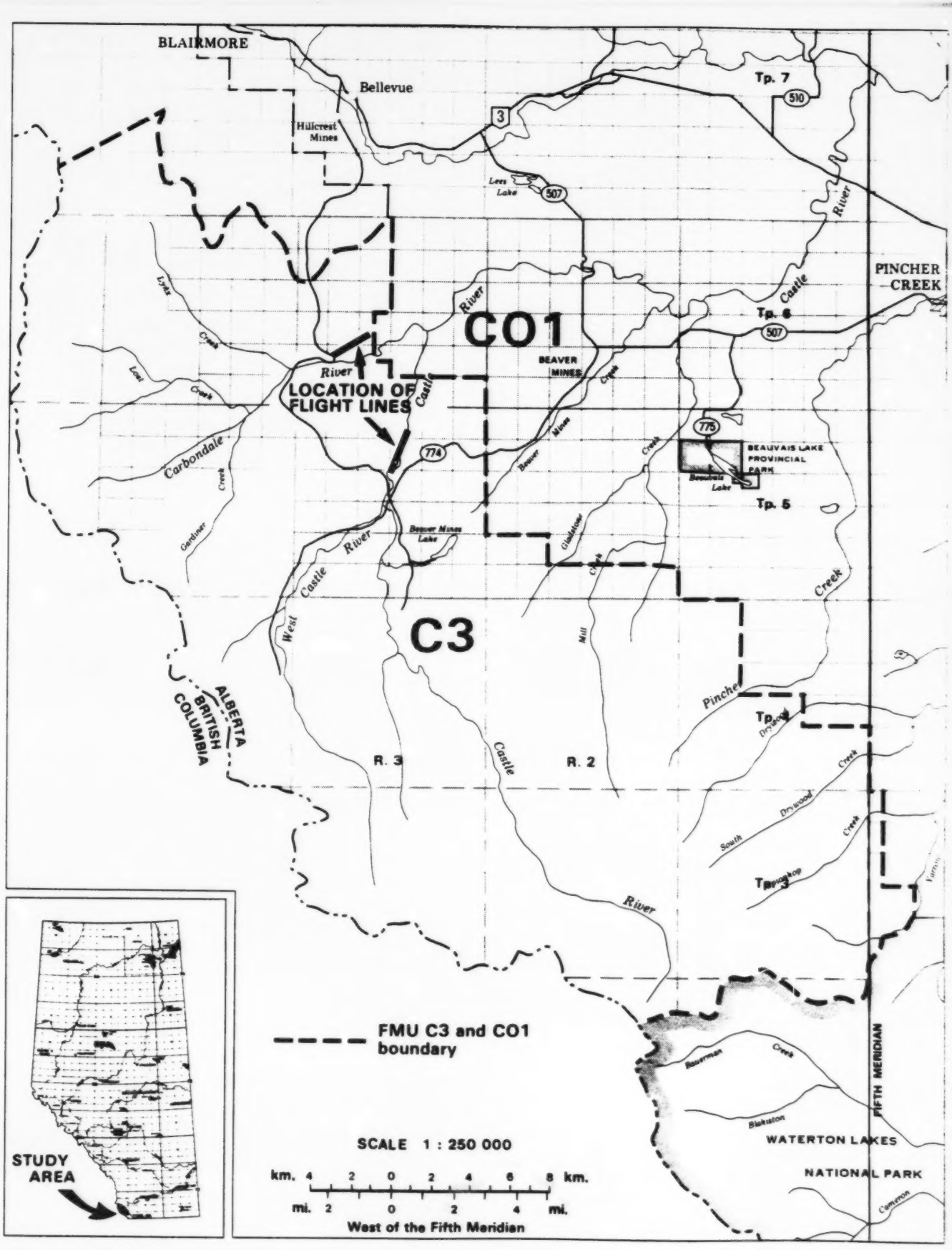

Fig. 1 Location of Large Scale Photo Flight Lines in the Study Area

3. METHODS

3.1 Office Preparation

Office preparation for the photo acquisition mission is one of the most crucial stages in a LSP project. The one major goal attempted in this project was to acquire duplicate LSP coverage of two strips with 70-mm color (Kodak 2445) and color infrared (Kodak 2443) films for the interpretive comparison between the two film types.

The location of the two flight lines was chosen on 1:20 000 Kodak aerocolor (Kodak 2445) 23 x 23 cm contact prints. In the placement of the two flight lines, consideration was given to the availability of obvious tie points (e.g. clearings, river bends, road intersections) along the path of flight. Tie points would assist the second pass over the flight line to be duplicated.

Office preparation also included the determination of photo acquisition variables such as camera settings, flying height, intervalometer settings, aircraft speed, etc., in order to render high quality photography.

3.2 Large-Scale Photo Acquisition System

Aerial photography was acquired using the Northern Forest Research Centres (NoFRC) aerial camera system, based on a request by the Reource Evaluation Branch.

> "The NoFRC camera system, described in Hall, 1984, is composed of two 70-mm Vinten aerial cameras, a Honeywell radar altimeter, and a black-and-white video camera housed in a pod built by Didec R. and D. Ltd.[1]. The pod is externally mounted under a Bell 206B jet ranger helicopter (Figure 2). In addition, an instrumentation rack, also built by Didec R. and D. Ltd., is mounted in the rear cabin of the Bell 206B (Figure 3). The analogue radar height indicator, mechanical intervalometer (Van Eck and Bihuniak 1978), batteries and video monitor and recorder are mounted on the rack. Both the rack and pod are Ministry of Transport tested and are approved for Bell 206B and Cessna 185 aircraft. Lenses of different focal lengths are mounted on the cameras. The cameras are fired sequentially, resulting in simultaneous localized and broader views of the terrain. With two cameras, the system is therefore capable of acquiring two scales of photography using different films. This is particularly useful for tracking purposes, because film format results in small areas being photographed at large

---

[1] 17th Avenue, R.R. 2, Markham, Ontario, L3P 3J3

Figure 2. BELL 206B HELICOPTER WITH NoFRC LSP ACQUISITION

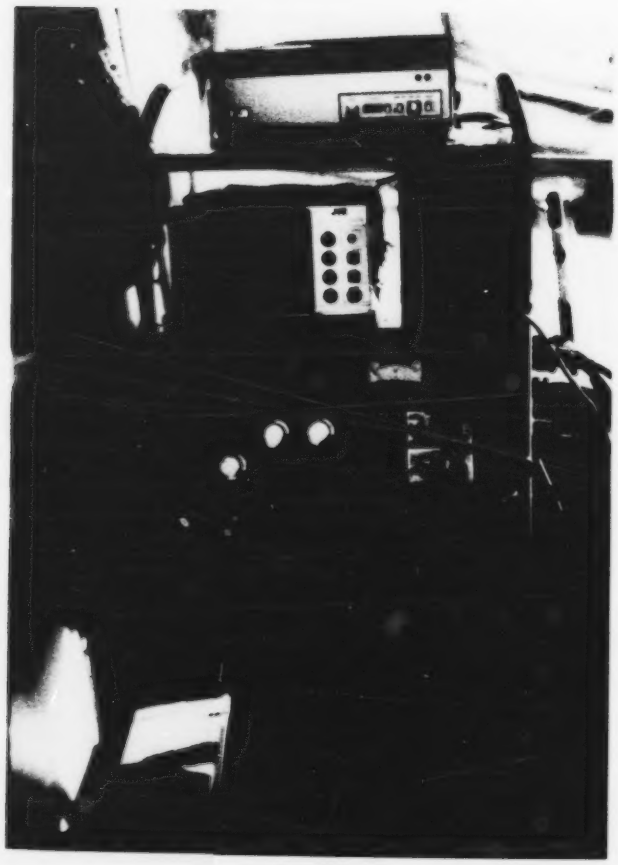

Figure 3. INSTRUMENTATION RACK FOR NoFRC LSP ACQUISITION SYSTEM

scales (Kirby and Hall et al. 1980) at a flying height of 150 m."

During photo acquisition, a navigator and camera operator are required in the aircraft with the pilot.

1:500 scale photography was acquired using a camera with a focal length of 281.9 mm. The tracking camera had a lens with a focal length of 77.45 mm, and would therefore acquire photography at a scale of 1:2 000 at a flying height of 150 m. In each of the two passes over each flight line, the film types, Kodak Aerochrome Infrared 2443 and Kodak Color Negative 2445 were alternated in each camera.

3.3 Large-Scale Photo Acquisition

Prior to the photo acquisition mission, all in-flight camera settings were calculated in order to avoid unnecessary calculations during the photo mission. Through the use of a Flight Planning computer program from NoFRC that was compatible with a Hewlett Packard 9825A micro-processor, all of the in-flight equipment settings including film consumption rates were determined.

Careful pre-flight planning resulted in good quality photography.

Before each flight line was photographed, one dummy pass was flown. This helped the aircraft pilot orient himself to the correct

location of each line. Good flight line orientation increases the probability of the pilot keeping the aircraft on course to provide the duplicate coverage of each flight line. The difficulty, however, was with a film format of 70-mm, a flying height of 150 m, and a focal length of 281.9 mm, the resulting area of ground coverage would be equivalent to a strip 35 m wide. It was critical for the navigator to keep the pilot on course at all times. The project area is known for its high wind gusts, which could affect aircraft navigation.

The NoFRC operated the equipment during the photo acquisition stages. Resource Evaluation staff provided ground data collection, aircraft and navigation personnel.

Upon completion of photo acquisition, all exposed film was sent to the National Air Photo Library[2] for processing and printing. Positive paper contact prints of the Kodak Aerochrome Infrared 2443, as well as diapositives, were obtained. Contact prints were produced of the infrared film as these would be more convenient than diapositives to use in the field.

After receiving all processed film, the film product was evaluated. Both flight lines of Kodak Aerocolor Negative 2445 were of good

---

[2] Energy, Mines and Resources, National Air Photo Library, Reproduction Centre, 615 Booth Street, Ottawa, Ontario, Canada, K1A 0E9.

quality, as was one flight line of Kodak Aerochrome Infrared 2443. The other flight line of Kodak Aerochrome Infrared (Kodak 2443) over the Castle Range Exposure was rejected, since it was under-exposed due to cloud shadows on the date of exposure.

3.4 Track Recovery

Because of the need to locate individual LSP frame locations on the ground for field sampling at a later date, track recovery occurred. This was done by using the 1:2 000 tracking photography to "bridge the scale gap" between the 1:500 LSP and the 1:20 000 medium-scale photography. The 1:20 000 scale photography was the same photography used for navigation during the photo acquisition mission. All tracking photo frames were annotated and assigned a frame and roll number. Every tenth tracking photo frame was located and indexed on the medium scale photography. Upon completion of track recovery, the path of flight with each emulsion over each flight line was evident. To determine any 1:500 LSP location, a table was constructed which acted as a cross-reference between corresponding 1:2 000 and 1:500 photo frames (Table 1).

The method used to determine a LSP frame location on the 1:20 000 scale photography was, first, to identify that location on the 1:20 000 scale photography, and second, to determine the tracking frame number as annotated on the 1:20 000 scale photography. The final step was to locate the tracking frame number in the table (Table 1) and to read across to the LSP frame number.

Table 1

CROSS REFERENCE TABLE IN RELATING 1:2 000 TRACKING PHOTOGRAPHY TO 1:500 LSP

Line #13 W-E

Roll #7 Color 1:500 LSP	Roll #7 CIR 1:2 000 TRACKING
Frames 02-262	Frames 122-203
06	123
12	125
18	127
24	128
30	130
36	132
42	133
48	135
etc.	etc.

involved going to the table (Figure 4) to locate the tracking frame number and to read across to the LSP frame number.

4. FIELD SAMPLING

A total of 117 sites were located in the field using the contact prints of the Kodak Aerochrome Infrared 2443 film and the Kodak Color Negative 2445 film. Field sites were located randomly. The field crew located as many sites as possible on the two emulsions on each flight line in the time alloted for the field activities. If a one-species vegetative community was found on the ground and that vegetation was identifiable on the LSP, it was subsequently identified and the location was pinpricked on the LSP. If more than one species existed on the site, the percentage which each species contributed to that vegetative community was also recorded and its location pinpricked on the LSP. Information recorded applied to the immediate proximity of the pinprick location. Notes and comments were also made on tally forms which would help to distinguish between vegetative communities at a later date from the LSP. These notes and comments included subtle differences between vegetation appearance such as tone, contrast, shape, height, color of inflorescence, etc. It should also be noted that a large amount of the vegetation within the project area was in full climax. The color of vegetation inflorescence aided the field crew in locating many sites on the LSP.

5. POST FIELD

5.1 Summarizing Field Data

To summarize and tally all of the information collected, a table was drafted (Table 2) to indicate the species sampled in the field as well as to indicate on which LSP frame emulsion and on which flight line the sample was located. This table served as a means to observe which species were sampled most and least within the project area. Which species were field sampled with which film type (Kodak 2445 or Kodak 2443) was also determined from Table 2.

5.2 Photo Interpretation

Prior to the test all of the four interpreters had an opportunity to familiarize themselves with the vegetative samples within the project area. This was done by selecting some of the 70-mm LSP stereo pairs of Kodak 2445 and Kodak 2443 film which exhibited a representative sample of the predominant vegetation within the project area. Each of the four interpreters had the same opportunity for familiarization.

The four interpreters had varying degrees of photo interpretation experience with LSP and varying levels of experience with native range vegetation (Table 3).

TABLE 2

COLOR AND COLOR INFRARED
RANGE VEGETATION IDENTIFIED ON 70 mm - 1:500 LSP
IN CASTLE AND CARBONDALE EXCLOSURE AREAS

			1:500 Color				1:500 Color Infrared			
			Line 13 Carbondale Roll 7		Line 12 Castle Roll 7		Line 13 Carbondale Roll 4		Line 12 Castle Roll 3	
	Scientific Name	Common Name	Frame #	Photo Ref.#	Frame #	Photo Ref.#	Frame #	Photo Ref.#	Frame	Photo Ref.#
1.	Heracleum lanatum	Cow parsnip			292;356;440	1;1;1				
2.	Salix sp.	Willow			290;356;384 447	10;2;4 1				
3.	Populus tremuloides	Aspen	29	2	356;419;440	3;5;5	52	1		
4.	Phleum pratense	Timothy			356	4				
5.	Cornus stolonifera	Red Osier Dogwood (open)			352	1				
6.	Cornus stolonifera	Red Osier Dogwood (forest)			352	2				
7.	Phleum sp. Achillea sp. Potentilla sp. Grindelia sp.	Timothy Yarrow Cinquefoil Gumweed			352	3				
8.	Elaeagnus commutata	Silverberry, Wolf willow			384;456	1;1				
9.	Amelanchier alnifolia Symphoricarpos occidentalis	5% - Saskatoon 10% - Snowberry			384	2	294	3,7		
10.	Amelanchier alnifolia Symphoricarpos occidentalis Elaeagnus commutata	15% - Saskatoon 5% - Snowberry 10% - Wolf willow			384	3				
11.	Arctostaphylos uva-ursi	Bearberry			290;294;379	4;1;1	52	4		
12.	Antennaria sp. Selaginella densa	Pussy toes Little Club Moss			387;395;467 387	1;2;1 2				
13.	Pinus contorta	Lodgepole pine	237	4,5	266;272;292 336;387;456	1,3;1;4,5,6 3;3;4	255;294	3;12,13		
14.	Potentilla fruticosa	Shrubby cinquefoil			290;292;387 395;404;419	7;2;4 1;2;3				
15.	Aster sp. Phleum pratense Potentilla diversifolia Solidago sp.	Aster Timothy Smooth-leaved cinquefoil Golden rod			395	3				
16.	Bromus sp. Agropyron sp. Epilobium sp.	Brome Wheatgrass Willowherb, fireweed			395	4				
	etc.									

Each interpreter spent one day attempting to identify the vegetation found at the pinpricked locations on the two LSP emulsions. With the Kodak 2443 emulsion, it should be noted that interpretation was carried out from the original diapositives and not from the contact prints.

Stereo viewing of the LSP frames was done on a Carl Ziess Jena Interpretoscope provided by the Department of Environment, Alberta Remote Sensing Centre.

During the interpretation exercise, the interpreter would record the LSP frame number, film emulsion type and species found at the pinpricked location by using the same number assigned to the site when the field work occurred. With the aid of the pinpricked photos, each interpreter was able to view the same location, verified by the field crew on the ground.

Table 3

EXPERIENCE LEVELS OF INTERPRETERS A, B, C AND D

	INTERPRETERS			
	A	B	C	D
Range Vegetation: Ground	7.0 yrs.	0.5 yrs.	1.5 yrs.	3.0 yrs.
Photo Interpretation: Native Range Vegetation	5.0 yrs.	1.0 yrs.	0.0 yrs.	0.0 yrs.
Forest Inventory	0.5 yrs	11.0 yrs.	4.0 yrs.	3.0 yrs.
Ground experience in Project Area	1.0 yrs.	0.1 yrs.	0.0 yrs.	0.0 yrs.
Experience Interperting LSP	1.0 mth.	4.0 yrs.	4.0 yrs.	4.0 yrs.

6. RESULTS

The results were complied and analysed in two stages. First analysed were the results of each interpreter on the identification of vegetation at sites where only one species occurred (see Appendix 1). Second analysed were the results of each interpreter on the identification of vegetation at sites where more than one species occurred (see Appendces 2-5). This approach was used to simplify calculations. Also, three of the four interpreters were unaware that more than one species could occur at a photo location.

The interpreters' results are presented for the photo locations where one species occurred in Appendix 1. The results of the interpreters' ability at interpreting range vegetation where more than one species occurred at photo locations is presented in Appendices 2-5.

Interpreters A, C and D had better results at interpreting native range vegetation from the color infrared (Kodak 2443) film. This may have been due to the better resolution of color infrared (Kodak 2443) as the film used during the interpretation exercise was the original diapositives. All of the four interpreters noted that the color infrared (Kodak 2443) emulsion did exhibit more subtle tonal

differences between vegetation appearance than could be seen on the 2445. This corresponds with other reports of other researchers (Driscoll and Coleman 1974).

There was also a strong correlation between interpreter experience and the ability to interpret native range vegetation from color (Kodak 2445) and color-infrared (Kodak 2443) emulsions. Interpreter A was the most experienced in all aspects of dealing with native range vegetation and obtained the most accurate results (Table 4). The poorest results came from interpreters C and D, possibly because they had the least experience in all aspects of native range vegetation (Table 4). Furthermore, interpreters C and D did not have the opportunity to become familiar with the vegetation on the ground within the project area.

There were approximately 50 per cent more vegetative samples located on the color (Kodak 2445) emulsion than on the color infrared (Kodak 2443) emulsion. The project therefore did not permit as good a comparison between the two emulsions as was originally anticipated.

7. CONCLUSION

It was determined that native range vegetation can be identified from 1:500 LSP and with greater accuracy from color infrared (Kodak 2443) emulsion. This study revealed that numerous vegetation species could be reliably identified 100 per cent of the time (Appendix 1).

The factors which enalbed the interpreters to achieve the best results include: familiarity with the vegetation within the project area, familiarity with native range vegetation, air photo interpretation experience, film type and experience with LSP.

This scientific test of LSP for range management practices is considered exploratory only, in order to ascertain the areas where LSP can be used to advantage for range assessments. LSP could play an important role as a sampling technique within a multi-stage sampling scheme of provincial native range lands. With todays increasing costs and shortage of sufficient field personnel to carry out intensive field assessments and inventory surveys, LSP could be a vialbe alternative.

8. RECOMMENDATIONS

One of the major objectives in this project was to compare color (Kodak 2445) and color infrared (Kodak 2443) to determine which emulsion was more suitable for the interpretation of native range vegetation. A greater degree of success would have occurred in acquiring duplicate coverage of the two flight lines with both emulsions if a more detailed network of ground targets had been established. This would have permitted more accurate air navigation during photo acquisition. Another factor worth considering is the use of a 152 mm focal length lens on the LSP camera during photo acquisition as opposed to the 281.9 mm telephoto lens. Upon changing to a focal length of 152 mm, the aircraft flying height would need to be reduced by one-half to acquire the desired photo scale of 1:500. The above two factors would greatly increase the probability of duplicating a flight line with two film emulsions.

When exposing color infrared (Kodak 2443) film, or any other film, it is recommended to carry a light meter within the aircraft during LSP acquisition in order to set more presisely, the camera exposure. It should be noted, however, that a light meter cannot be used as a precise instrument for this application; inconsistencies with the ASA - EAFS film speed rating systems and the meter calibrated for visible light must be considered. The light meter is used as an orientation

device and can be particularly useful if some tests are performed prior to the time of photo acquisition. Consideration might also be given to having the film emulsions calibrated by obtaining sensotometric data prior to the photo acquisition mission. All aerial film emulsions tend to degrade in time, particularly Kodak 2443.

The timing of LSP acquisition over native range vegetation should coincide as closely as possible with vegetation climax. Vegetation inflorescence is a major key in species identification, particularly with very small, inconspicuous plants. Field-work and ground truthing must occur as soon as possible after photo acquisition but prior to vegetation senescence so as to identify species reliably from LSP.

It was realized that the method used for track recovery on the 1:20 000 scale photography was quite inefficient. That is, in future LSP projects, the actual LSP frame numbers should be annotated on the medium-scale photography (every 10th frame) instead of annotating the tracking frame numbers. This would be done by locating every 10th LSP frame principal point location directly upon the equivalent tracking frame, then transferring those points onto the medium-scale photography with their corresponding LSP frame number.

A means of tabling and reporting interpretation accuracy must be clearly specified in order to deal with large numbers of vegetative sites used in an interpretation project. Good data management will provide in information which is easier to analyze and report.

APPENDIX 1

RESULTS FOR INTERPRETER A, B, C AND D FOR SITES WHERE ONE SPECIES OCCURRED

SCIENTIFIC NAME	TOTAL NUMBER OF SITES PER SPECIES			INTERPRETER A			INTERPRETER B			INTERPRETER C			INTERPRETER D		
Group Number	#COL	COL/CIR	#CIR	% of Total Identified (COL/CIR)	% Color Identified	% CIR Identified	% of Total Identified (COL/CIR)	% Color Identified	% CIR Identified	% of Total Identified (COL/CIR)	% Color Identified	% CIR Identified	% of Total Identified (COL/CIR)	% Color Identified	% CIR Identified
0. Grasses	12	16	4	75	67	100	81	83	100	81	75	100	81	75	100
1. Heracleum lanatum	3	3	0	100	100	/	100	100	/	100	100	/	100	100	/
2. Salix sp.	5	5	0	100	100	/	100	100	/	60	60	/	60	60	/
3. Populus tremuloides	9	12	3	91	89	100	83	89	66	100	100	67	75	78	67
4. Poleum pratense	1	1	0	100	100	/	100	100	/	100	100	/	100	100	/
5. Cornus stolonifera	1	1	0	100	100	/	0	0	/	0	0	/	0	0	/
6. Elaeagnus commutata	1	1	0	100	100	/	100	100	/	100	100	/	50	50	/
8. Elaeagnus commutata	2	2	0	100	100	/	100	100	/	100	100	/	75	71	100
11. Arctostaphylos uva-ursi	7	8	1	50	43	100	75	71	100	75	71	100	80	75	100
13. Pinus contorta	12	15	3	73	67	100	87	92	67	53	50	67	67	67	/
16. Potentilla fruticosa	6	6	0	83	83	/	67	67	/	67	67	/	67	67	/
17. Populus balsamifera	6	9	3	89	100	67	78	83	67	22	33	0	11	17	0
19. Amelanchier alnifolia	3	5	2	80	67	100	80	67	50	60	100	0	100	100	100
26. Symphoricarpos albus	4	7	3	100	100	100	57	75	33	71	50	100	14	25	0
30. Pseudotsuga menziesii	3	5	2	100	100	100	60	67	50	80	100	50	100	100	100
40. Balsamorhiza sagittata	1	2	1	100	100	100	100	100	100	100	100	100	100	100	100
53. Anthil	2	2	0	50	50	/	0	0	/	100	100	/	100	100	/
65. Castellija miniata	3	3	0	0	0	/	33	33	/	67	67	/	100	100	/
66. Crotaegus columbiana	2	2	0	50	50	/	50	50	/	0	0	/	50	50	/
71. Mole hill	1	1	0	100	100	/	100	100	/	0	0	/	0	0	/
73. Geranium sp.	2	2	0	0	0	/	100	100	/	0	0	/	0	0	/
77. Arisaemia sp.	2	2	0	100	100	/	100	100	/	0	0	/	0	0	/
79. Selaginella dense	1	1	0	100	100	/	0	0	/	0	0	/	100	100	/
81. Delphinium glauca	1	1	0	100	100	/	0	0	/	0	0	/	0	0	/
92. Juniperus sp.	3	3	0	100	100	/	67	67	/	33	33	/	67	67	/
95. Potentilla diversifolia	2	2	0	50	50	/	50	50	/	0	0	/	100	100	/
97. Dead conifer	3	3	0	33	33	/	67	67	/	67	67	/	100	100	/
100. Lupinus sp.	3	3	0	33	33	/	0	0	/	0	0	/	0	0	/
101. Solidago sp.	1	1	0	100	100	/	0	0	/	0	0	/	0	0	/
107. Potentilla fruticosa	1	1	0	100	100	/	0	0	/	0	0	/	100	100	/
110. Sand and bare ground	2	2	0	100	100	/	100	100	/	100	100	/	100	100	/
111. Dryas sp.	1	1	0	100	100	/	100	100	/	0	0	/	0	0	/
TOTALS:	106	127	22	9 684	7 807	2 101	9 101	7 701	1 399	7 589	6 098	1 562	8 196	6 754	1 501
WEIGHTED AVERAGES:				76.35	76.45	95.55	71.75	73.35	63.65	59.85	58.35	70.55	64.55	63.85	68.25

N.B. / indicates that no sites existed on the CIR containing these species.

APPENDIX 2

Interpreter A

LISTINGS PER INTERPRETER OF WHICH SPECIES COULD BE CORRECTLY IDENTIFIED FROM SITES COMPOSED OF MORE THAN 1 SPECIES ON 70-mm COLOR (KODAK 2445) AND COLOR INFRARED (KODAK 2443) FILM

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
10	Color	Amelanchier alnifolia Symphoricarpos albus Elaeagnus commutata	Symphoricarpos albus Elaeagnus commutata
10a	Color	Amelanchier alnifolia Symphoricarpos albus Elaeagnus commutata	Elaeagnus commutata
18	CIR	Populus balsamifera Amelanchier alnifolia	Amelanchier alnifolia
18a (2nd occurrence)	Color	Populus balsamifera Amelanchier alnifolia	Populus tremuloides Amelanchier alnifolia
24	CIR	Rosa acicularis Symphoricarpos albus Festuca sp. Achillea millefolium	Grasses and Forbs
28	CIR	Crataegus douglasii Symphoricarpos albus	Crataegus douglasii
29	CIR	Symphoricarpos albus Prunus sp.	Symphoricarpos albus
31	CIR	Rosa acicularis Amelanchier alnifolia Symphoricarpos albus	Symphoricarpos albus

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
32	CIR	Elaeagnus commuatata Cornus stolonifera Symphoricarpos albus Alnus sp.	Elaeagnus commutata
36	CIR	Arctostaphylos uva-ursi Festuca sp.	Arctostaphylos uva-ursi
41	CIR	Amelanchier alnifolia Balsamorhiza sagitatta	Balsamorhiza sagitatta
42	Color	Amelanchier alnifolia Symphoricarpos albus Linaria sp.	Amelanchier alnifolia Symphoricarpos albus
42	CIR	Amelanchier alnifolia Symphoricarpos albus Linaria sp.	Amelanchier alnifolia
46	CIR	Festuca sp. Poa sp. Gaillardia sp. Achillea millefolium Koeleria cristata	Grass
47	CIR	Amelanchier alnifolia Prunus sp. Symphoricarpos albus	Symphoricarpos albus
50	Color	Festuca sp. Potentilla diversifolia Aster	Grass
52	Color	Symphoricarpos albus Urtica sp.	Symphoricarpos albus

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
56	Color	Symphoricarpos albus Bromus sp. Elymus sp. Geranium sp. Rosa acicularis	Symphoricarpos albus
58	Color	Arctostaphylos uva-ursi Berberis repens Symphoricarpos albus Amelanchier alnifolia	Amelanchier alnifolia
62	Color	Linaria sp. Symphoricarpos albus Rosa acicularis Potentilla diversifolia	Symphoricarpos albus Rosa acicularis
67	Color	Populus tremuloides Amelanchier alnifolia Arctostaphylos uva-ursi	Populus tremuloides Symphoricarpos albus
68	Color	Populus tremuloides Prunus sp. Amelanchier alnifolia Symphoricarpos albus	Populus tremuloides
70	Color	Amelanchier alnifolia Agropyron trachycaulum Koeleria cristata	Amelanchier alnifolia
72	Color	Symphoricarpos albus Amelanchier alnifolia Potentilla diversifolia	Symphoricarpos albus Amelanchier alnifolia

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
89	Color	Amelanchier alnifolia Symphoricarpos albus Pseudotsuga menziesii	Amelanchier alnifolia Symphoricarpos albus
90	Color	Festuca sp. Phleum pratense Achillea millefolium Rosa Artemisia sp.	Grass
96	Color	Amelanchier alnifolia Aster sp. Rhinathus Fragaria sp. Galium sp. Shepherdia canadensis Selaginella densa	Amelanchier alnifolia
104	Color	Symphoricarpos albus Lonicera sp. Epilobium angustifolium Urtica sp.	Symphoricarpos albus

APPENDIX 3

Interpreter B

LISTINGS PER INTERPRETER OF WHICH SPECIES COULD BE CORRECTLY IDENTIFIED FROM SITES COMPOSED OF MORE THAN 1 SPECIES ON-70 mm COLOR (KODAK 2445) AND COLOR INFRARED (KODAK 2443) FILM

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
10	Color	Amelanchier alnifolia Symphoricarpos albus Elaeagnus commutata	Symphoricarpos albus Elaeagnus commutata
15	Color	Aster sp. Phleum pratense Potentilla diversifolia Solidago sp.	Grass
16	Color	Bromus sp. Agropyron sp. Epilobium sp.	Grass
20	CIR	Oxytropis sp. Festuca sp.	Grass in clumps
25	CIR	Symphoricarpos albus Festuca sp. Poa pratense Agropyron trachycaulum	Symphoricarpos albus
28	CIR	Crataegus douglasii Symphoricarpos albus	Symphoricarpos albus Crataegus douglasii
31	CIR	Rosa acicularis Amelanchier alnifolia Symphoricarpos albus	Symphoricarpos albus

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
32	CIR	Elaeagnus commutata Cornus stolonifera Symphoricarpos albus Alnus sp.	Elaeagnus commutata
42	Color	Amelanchier alnifolia Symphoricarpos albus Linaria sp.	Symphoricarpos albus
42 (2nd occurrence)	CIR	Amelanchier alnifolia Symphoricarpos albus Linaria sp.	Symphoricarpos albus
50	Color	Festuca sp. Potentilla diversifolia Aster	Grass
51	Color	Fragaria sp. Symphoricarpos albus Lupinus sp. Rosa acicularis Aster	Rosa sp.
52	Color	Symphoricarpos albus Urtica sp.	Symphoricarpos albus
60	Color	Gaillardia sp. Chrysopsis villosa Achillea millefolium	Chrysopsis sp.
67	Color	Populus tremuloides Prunus sp. Amelanchier alnifolia Symphoricarpos albus	Symphoricarpos albus

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
68	Color	Populus tremuloides Prunus sp. Amelanchier alnifolia Symphoricarpos albus	Symphoricarpos albus
69	Color	Overgrazed:	
		Achillea millefolium Artemisia sp. Antennaria sp. Selaginella densa Astragalus crassicarpus	Grass Soil
72	Color	Symphoricarpus albus Amelanchier alnifolia Potentilla diversifolia	Amelanchier alnifolia
89	Color	Amelanchier alnifolia Symphoricarpos albus Pseudotsuga menziesii	Symphoricarpos albus

APPENDIX 4

Interpreter C

LISTINGS PER INTERPRETER OF WHICH SPECIES COULD BE CORRECTLY IDENTIFIED FROM SITES COMPOSED OF MORE THAN 1 SPECIES ON 70-mm COLOR (KODAK 2445) AND COLOR INFRARED (KODAK 2443) FILM

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
12	Color	Antennaria sp. Selaginella densa	Selaginella densa
15	Color	Aster sp. Phleum pratense Potentilla diversifolia Solidago sp.	Grasses
16	Color	Bromus sp. Agropyron sp. Epilobium sp.	Grasses
18	Color	Populus balsamifera Amelanchier alnifolia	Amelanchier alnifolia
20	Color	Oxytropis sp. Festuca sp.	Grasses
29	CIR	Symphoricarpos albus Prunus sp.	Symphoricarpos albus
32	CIR	Elaeagnus commutata Cornus stolonifera Symphoricarpos albus Alnus sp.	Elaeagnus commutata
36	CIR	Arctostaphylos uva-ursi Festuca sp.	Arctostaphylos uva-ursi

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
42	Color	Amelanchier alnifolia Symphoricarpos albus Linaria sp.	Symphoricarpos albus
50	Color	Festuca sp. Potentilla diversifolia Aster	Grasses
62	Color	Linaria sp. Symphoricarpos albus Rosa acicularis Potentilla diversifolia	Symphoricarpos albus
108	Color	Symphoricarpos albus Epilobium antustifolium	Symphoricarpos albus

APPENDIX 5

Interpreter D

LISTINGS PER INTERPRETER OF WHICH SPECIES COULD BE CORRECTLY IDENTIFIED FROM SITES COMPOSED OF MORE THAN 1 SPECIES ON 70-mm COLOR (KODAK 2445) AND COLOR INFRARED (KODAK 2443) FILM

Species Group #	Film Emulsion	Ground Truthed Species Composition	Species Identified Through Interpretation
10	Color	Amelanchier alnifolia Symphoricarpos albus Elaeagnus commutata	Amelanchier alnifolia
18	Color	Populus balsamifera Amelanchier alnifolia	Amelanchier alnifolia
18 (2nd occurrence)	CIR	Populus balsamifera Amelanchier alnifolia	Amelanchier alnifolia
33	CIR	Antennaria sp. Koeleria sp. Artemisia sp. Festuca sp.	Grass
58	Color	Arctostaphylos uva-ursi Berberis repens Symphoricarpos albus Amelanchier alnifolia	Arctostaphylos uva-ursi
59	Color	Amelanchier alnifolia Arctostaphylos uva-ursi	Arctostaphylos uva-ursi
68	Color	Populus tremuloides Prunus sp. Amelanchier alnifolia Symphoricarpos albus	Amelanchier alnifolia

REFERENCES

Aldred, A. H. and J. J. Lowe. 1978. Application of Large-Scale Photos to a Forest Inventory in Alberta. Environment Canada, Canadian Forest Service, Forest Management Int., Ottawa, Ontario. Inf. Rep. FMR-X-107

American Society of Photogrammetry. 1980. Manual of Photogrammetry. Fourth Edition. Slama, C., Theurer, C., Henriksen, W., editors. Falls Church, Va.

Brock, G. C. 1952. Physical Aspects of Aerial Photography. Longmans, Green and Co., London.

Coish, C. and R. K. Nesby. 1984. Alberta Phase 3 Forest Inventory. Large-Scale Photography Procedures Draft. Alberta Energy and Natural Resources, Edmonton. ENR Report No. Dept. 55.

Colwell, R. N. 1971. Monitoring Earth Resources from Aircraft and Spacecraft. National Aeronautics and Space Administration. Washington, D.C. Report No. NASA SP-275.

Driscoll, R. S. 1971. Color aerial photography, a new view for range management. USDA Forest Service Research Paper. Report No. RM-67.

Driscoll, R.S. 1974. Use of Remote Sensing in Range and Forest Management. Proc. Great Plains Agric. Coun. pp. 111-133.

Driscoll, R. S. and M. D. Coleman. 1974. Color for Shrubs. Photogrammetric Engineering and Remote Sensing, Volume 15, pp. 451- 459. Supplement.

Eastman Kodak Company. 1982. Kodak Data for Aerial Photography. Fifth Edition. Eastman Kodak Company, New York.

Hall, R. J. 1984. Use of Large-Scale Aerial Photographs in Regeneration Assessments. Canadian Forest Service, Northern Forest Research Centre, Edmonton, Alberta. Inf. Rep. NOR-X-264.

Heintz, T. W. and J. R. Lewis and S. S. Waller. 1979. Low-Level Aerial Photography as a Management and Research Tool for Range Inventory. Jour. of Range Management. 32(4), July.

Holz, R. K. 1973. The Surveillant Science, Remote Sensing of the Environment. Boston, Houghton Mifflin Company.

Kirby, C. L. and R. J. Hall. 1980. The Large-Scale Photo Sampling System at the Northern Forest Research Centre. In Workshop for Practical Applications of Remote Sensing to Timber Inventory. Environment Canada, Canadian Forest Service, Northern Forest Research Centre, Edmonton, Alberta. Inf. Rep. NOR-X-224, pp. 66-74.

Price Waterhouse. 1984. NFRC Market Research Study - Large-Scale Photo Sampling System. Price Waterhouse Associates, Edmonton. Unpub. report for Environment Canada, March 30, 1984.

Spurr, S. H. 1960. Photogrammetry and Photo Interpretation. Second Edition, Ronald Press Co., New York.

Thompson, D. M. 1984. Intera Technologies Ltd. Remote Sensing for Brush Encroachment. Alberta Environment. Alberta Remote Sensing Centre. Publ. No. 84-1.